An Integrated Treatment Scheme for Removing Salinity and Toxicity from Waters Produced from Coal-Bed Methane Wells

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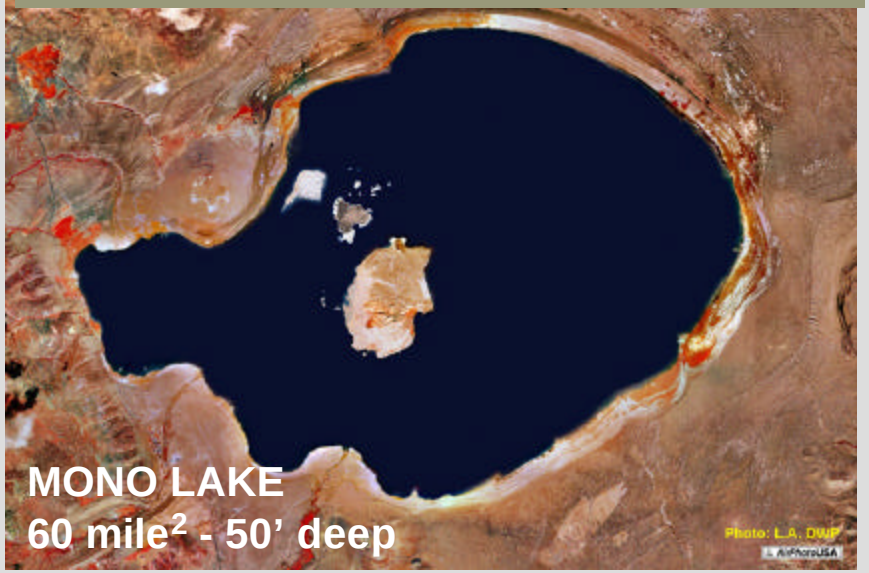
Idaho National Eng. & Env. Laboratory
University of Texas at El Paso
Double Eagle Petroleum Company

NGOTP
November 20, 2002

CBM Produced Waters

Produced Water Vol. Forecast 2011
Powder River Basin : 2 x 10^{10} bbl
(TDS: 270 – 2010 ppm)



- Potential for beneficial reuse.
- Vol Increases economic impacts of disposal options.
- Need to demonstrate a range of water management options. USEPA: 2001

"… the cumulative CBM produced water impacts and issues must be resolved now!" Schneider 2001, Montana DEQ

Salinity Range

100 – 170,000 ppm

Management Options

- Surface Discharge
- Evaporation
- Wetlands
- Reinjection

- Beneficial Uses – Need Salinity and Toxicity Reduction
  - Watering Livestock
  - Irrigation
  - Potable water

Beneficial Use of CBM Produced Waters

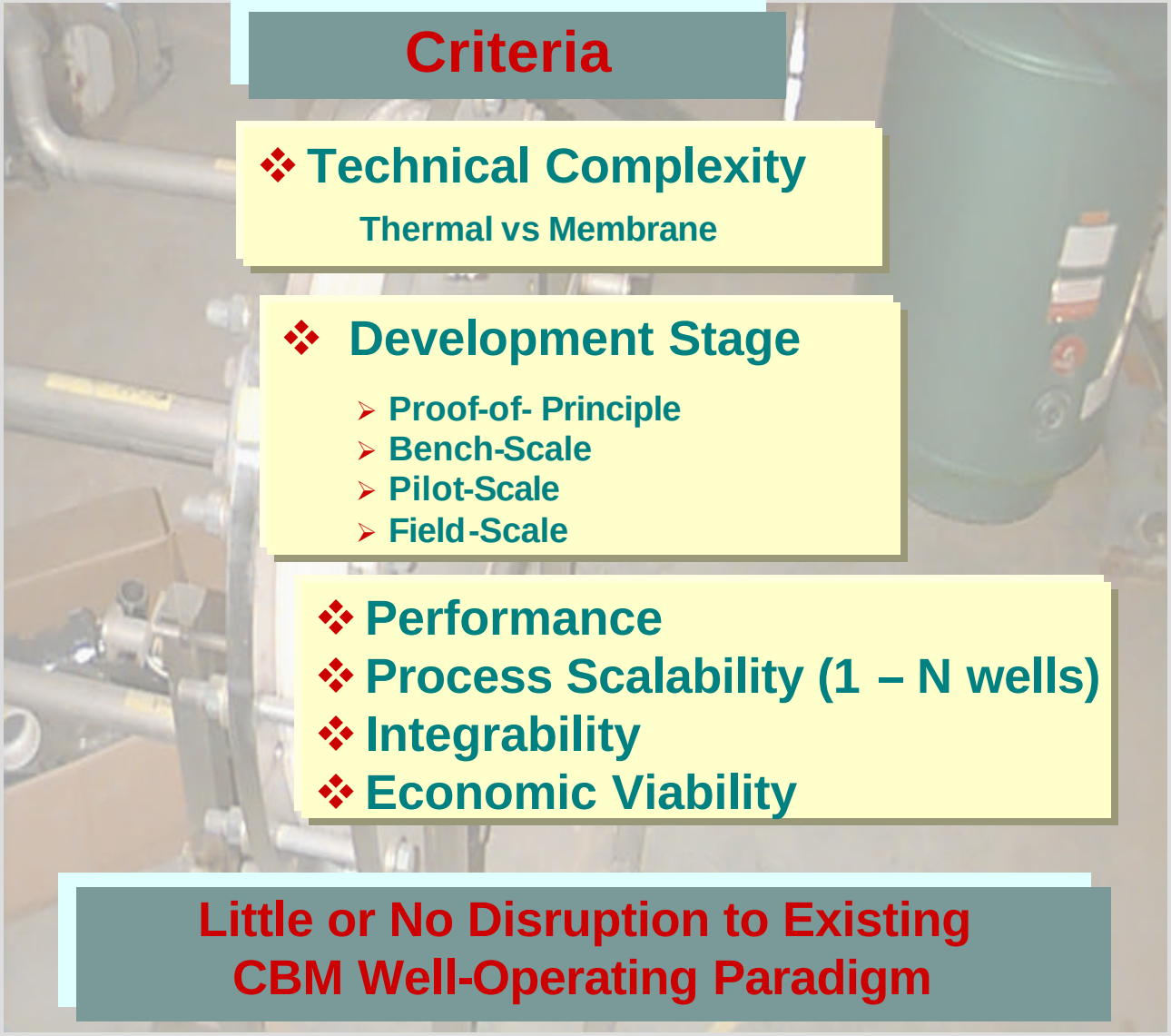
- Increasing demand for Livestock/Irrigation and Potable water.

- Current Technologies: *MSF, MED, VC, ED, FD*
  - Greater Capital Cost
  - Energy Intensive – Higher Operating Costs
  - Water Cost: **~ $0.27 - $0.40/bbl***

- Need CBM Water Treatment Technology
  - Reduced Capital Cost
  - Lower Energy Input & Operating Costs
  - Treated Water @ **< $0.10 - $0.15/bbl**

*Source: Davis (1993) CBM Produced Water Management Guide, GRI-93/0116, Gas Research Institute, Chicago

Technology Selection and Integration

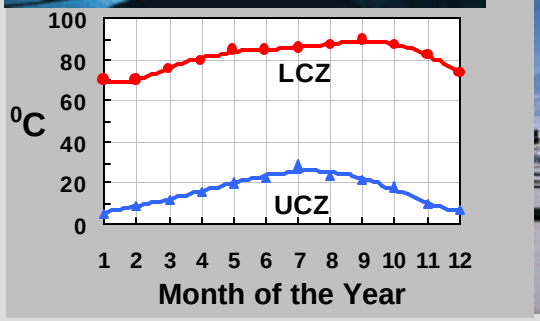


Criteria

- **Technical Complexity**
  - Thermal vs Membrane
- **Development Stage**
  - Proof-of- Principle
  - Bench-Scale
  - Pilot-Scale
  - Field-Scale
- **Performance**
- **Process Scalability (1 – N wells)**
- **Integrability**
- **Economic Viability**

Little or No Disruption to Existing CBM Well-Operating Paradigm

Salinity-Gradient Solar Pond



What Can SGSP System Deliver?

- Desalinazation: 1400 – 240,000 ppm
- Process Heat – Oil Recovery (Crude Oil /Brine Separation)
- Waste Brine Processing
- Baseload Power for Remote Locations
- Deliver Thermal Energy at ?T 50 ^{o}F

Salinity-Gradient Solar Pond at UTEP

System Performance

Influent Salinity:
1400 – 240,000 ppm

Reduction >99%
Salinity, Chloride, Sulfate, Sodium, Calcium

Treated Water Cost*

$0.08 - $0.10/bbl

- Industrial Process Heat Delivery (Commercial Manufacturer): since 1983
- Power Generation: 1986
- Desalination: 1987
- Zero Discharge Desalination: 2001

*Source: Esquivel (1991) Economic Feasibility of Utilizing Solar Pond Technology… Masters Thesis, UTEP

Freeze Desalinization

Pilot-Scale Freeze Desalination
Devil's Lake, North Dakota

System Performance*

Influent Salinity: 1400 – 5000 ppm

Reduction

- Salinity 80 – 90%
- SAR 65%
- COD 85%
- TOC 60%
- NO_3+NO_2 95%

- Desalinized Water 84%
- Treated Water Cost $0.05/bbl

*Source: Boysen et al. 1999, 2002. Bureau of Reclamation, US Dept of Interior.

Self-Assembled Monolayers on Mesoporous Silica (SAMMS) Technology

Adsorbs large quantities of metal and metalloids from water

Loading: ~ 40 – 600 mg/g SAMMS

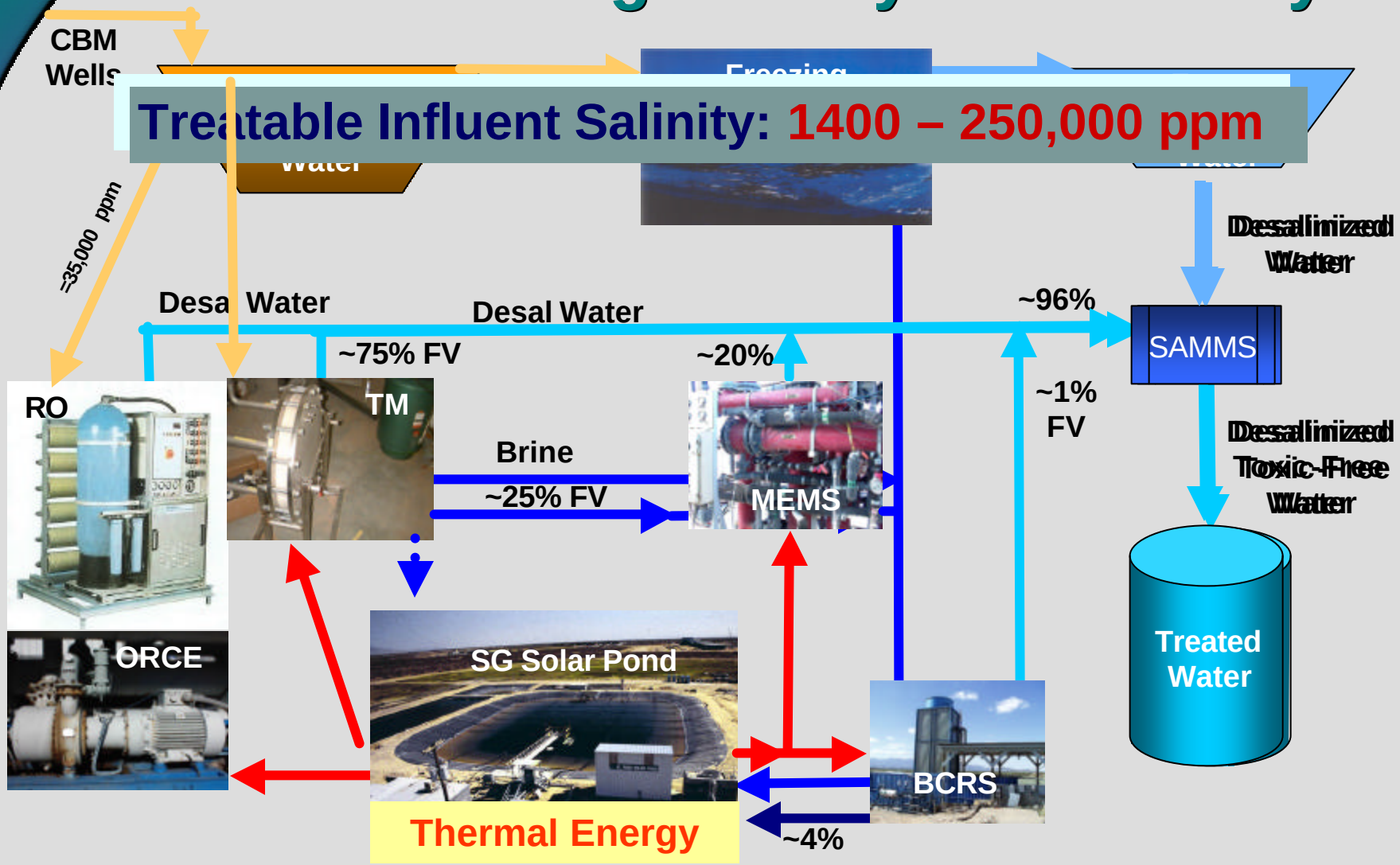
Kinetics: ~99.9% in 5 min.

Selectivity: Kd ~ 10^3 – 10^8 ml/g

SAMMS Type	Contaminant
thiol:	Cd, Cu, Pb, Hg, Ag
Cu-EDA:	As, Cr, Se, Mo, Tc
M-thiol:	I, Br
AP, PP, HOPO:	Th, U

Science, 276, 1997; Advanced Materials, 10, 1998 (cover); 1998 R&D 100 Award; Reports in Scientific American, Popular Science, Discover, Business Week, Chem & Engr. News, Nikkei Science

An Integrated Treatment System for Removing Salinity and Toxicity



Integrated Treatment System

Treated Water
A Valuable CO-PRODUCT

- Cost Effective (<$0.10/bbl)

CBM Water, Now a BY- PRODUCT

- Flexibility in Integration

- Scalable System
  - Number of Wells
  - Degree of Water Quality

- Other Applications: Oil, Gas, Mining Effluents

Little or No Disruption to Existing CBM Well-Operating Paradigm

Integrated Treatment System

Schedule

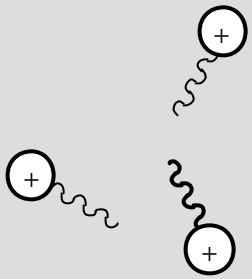
- Year 1
  - Lab-scale Performance Tests (CBM Sample Waters)
  - Review Data with Industrial Partner for Go-No Go Decision
- Year 2
  - Toxicity Removal Tests
  - Integrated Pilot-scale System Design
  - Review Test Data and the System Design: Go No Go Decision
- Year 3
  - Field Demonstration in Collaboration with Industrial Partners.

Integrated Treatment System

Research Team

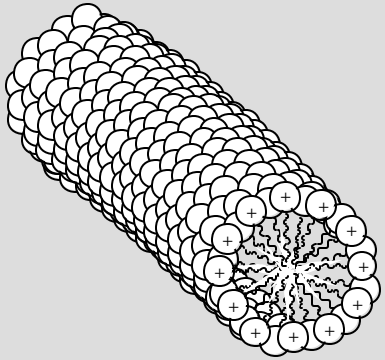
- **PNNL**
  Technology and System Integration, Toxic Removal Testing & Design
- **INEEL**
  Freeze Desalinization – Testing and System Design
- **UTEP**
  Salinity-Gradient Solar Pond – Testing and Design
- **Double Eagle Petroleum Co.**
  Industrial Partner
  Review Results: Input for Go-No Go Decision after 1st and 2nd Year

Synthesis of Nanoporous Ceramics Substrate

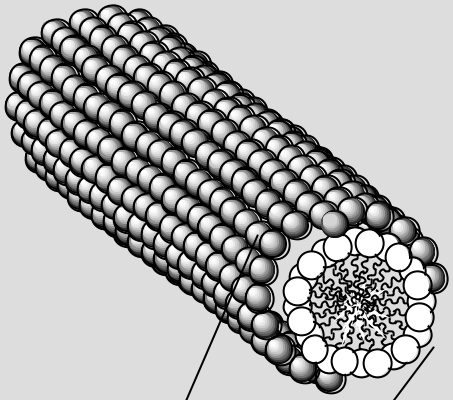


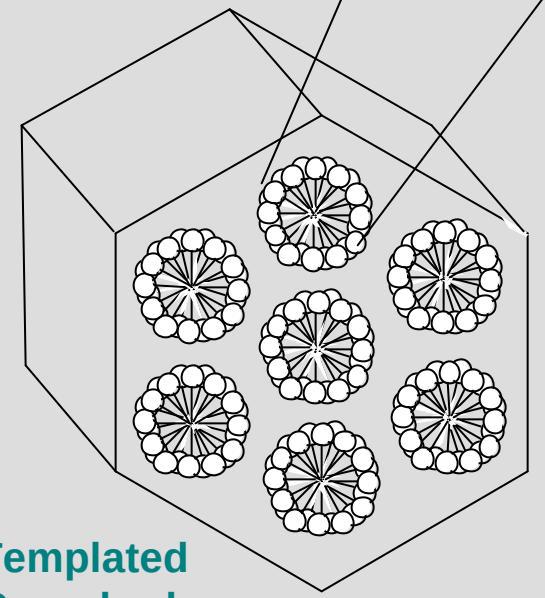
Cationic Surfactants

Micelles



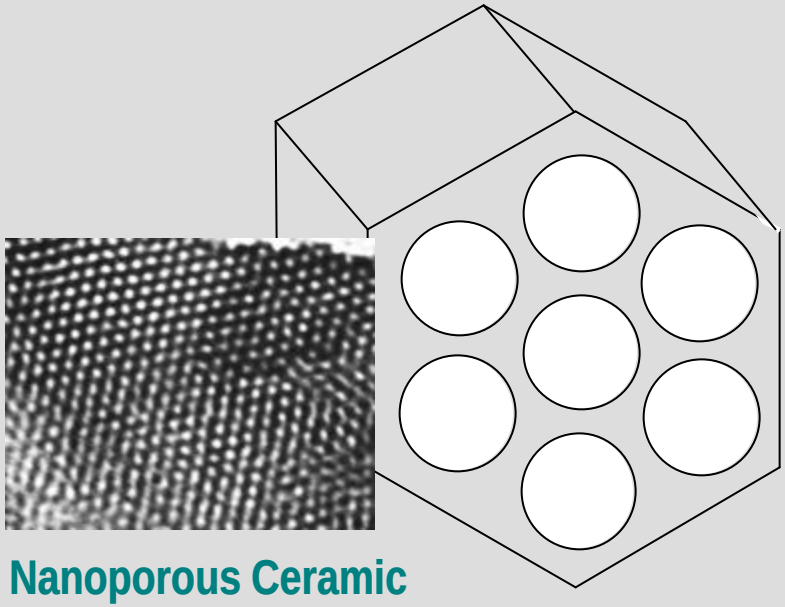
Sol-Gel





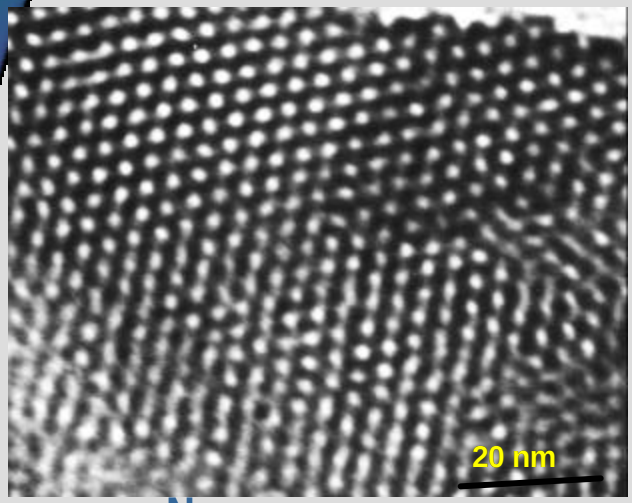
Templated Greenbody

Template Removal



Nanoporous Ceramic Substrate

SAMMS Material for Selective binding of Inorganic contaminant Species



Nanoporous
Ceramic substrate

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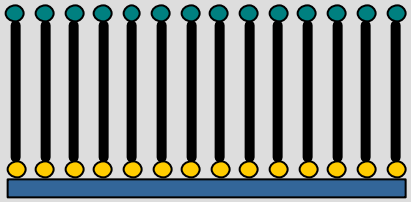
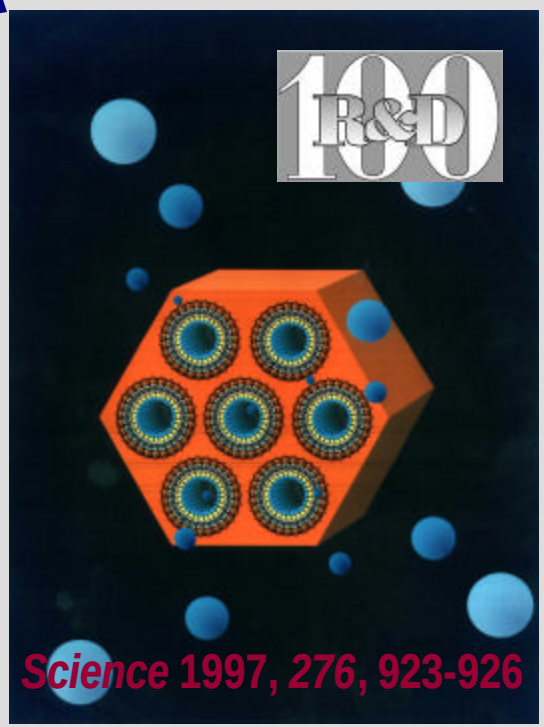


Self-assembled monolayers



US Patent # 6426326, 2 pending

TCLP Data for Hg-loaded thiol-SAMMS